# UNIVERSITY OF SOUTH AUSTRALIA

FACULTY OF ENGINEERING AND THE ENVIRONMENT

School of Geoinformatics, Planning and Building

Semester 1, 2000

# Geodetic Concepts : 10233

Time Allowed : 3 hours + 10 minutes reading time

**GENERAL INSTRUCTIONS TO CANDIDATES**:

Total Marks = 100

Attempt four (4) questions from Part A and all questions from Part B.

Part A equals 52% and Part B equals 48%. Marks for questions are shown in brackets.

Please ensure front of answer books are completed with your name, student I.D. number, course and section of the examination.

**ABBREVIATIONS AND CONSTANTS USED IN THIS EXAM**

AGD84 – Australian Geodetic Datum 1984
Semi major axis 6378160 metres
Flattening 1 : 298.25
WGS84 – World Geodetic System 1984
Semi major axis 6378137 metres
Flattening 1 : 298.257223563
GDA94 – Geodetic Datum of Australia 1994
Semi major axis 6378137 metres
Flattening 1 : 298. 257222101
UTM – Universal Transverse Mercator
GPS – Global Positioning System

# PART A

## QUESTION 1

(a) Define the following terms:

1) Great Circle
2) Small Circle
3) Spherical Excess
4) Spherical Triangle

(b) Stations S and F have the following latitude and longitude

| | | |
|---|---|---|
| S | $34^0$ 00' 00" S | $151^0$ 00' 00" E |
| F | $37^0$ 49' 00" N | $122^0$ 20' 00" W |

Spherical trigonometry is to be used to compute navigation information between the two points.

1) Draw a diagram illustrating the spherical triangle formed by S, F and the North Pole. Include the values of the known components of the triangle.
2) Describe how to compute the distance (in kilometres) between S and F (DO NOT PERFORM THE COMPUTATION).
3) Describe how to compute the azimuth from S to F and from F to S (DO NOT PERFORM THE COMPUTATION)
4) Describe the checks that you would perform on the results.

**(13)**

## QUESTION 2

(a) With the aid of a diagram, define the following terms:

1) Ellipsoidal Normal
2) Geodetic Latitude
3) Geocentric Latitude
4) Reduced Latitude

(b) Describe the difference between a Normal Section and a Geodesic. Use diagrams to illustrate your answer.

(c) Station S has the coordinates $34^0$ 00' 00" S, $151^0$ 00' 00" E. The azimuth and distance from S to station R are:

| | |
|---|---|
| Azimuth | $226^0$ 27' 21.24" |
| Distance | 1,275,322.191 metres. |

The coordinates of R are to be calculated (on an ellipsoid) to an accuracy of 1 centimetre. Whose formula(e) would you use to compute the coordinates of R? Give reasons for your answer.

**(13)**

## QUESTION 3

(a) Define the following terms

1) Conformality
2) Equidistance
3) Equivalence

(b) Using map projection terms, define the following map projections and describe their useful geographic extent:

1) Southern polar stereographic
2) Orthographic projection centered at $140^0$ E, $0^0$ N
3) Normal Mercator centered at $180^0$ East
4) Lambert conformal conic with standard parallels at $30^0$ S and $40^0$ S with a central meridian at $138^0$ E
5) Cassini centered at $135^0$ E, $0^0$ N.

**(13)**

## QUESTION 4

Stations A and B have the following latitude and longitude

| | | |
|---|---|---|
| A | $34^0$ 57' 27" S | $138^0$ 44' 21" E |
| B | $35^0$ 26' 33" S | $139^0$ 15' 40" E |

They are to be projected onto a Universal Transverse Mercator (UTM) projection.

(a) In which UTM zones do points A and B lie?

(b) Draw a diagram of a UTM grid illustrating:
1) The azimuth of station B from station A
2) The grid bearing of station B from station A
3) The grid convergence at station A

(c) Draw a second diagram of a UTM grid illustrating
1) The grid distance between stations A and B
2) The plane distance between stations A and B
3) The plane bearing of station B from stations A
4) The (T-t) correction at station A relating to the line from A to B

(d) Define the terms
1) Central scale factor
2) Line scale factor
3) Point scale factor
4) Central meridian

(e) Describe the similarities and differences between the Cassini and UTM projections. Use diagrams to illustrate your answer.
**(13)**

## QUESTION 5

Joe Newgrad is elated. He has just obtained his first job as a graduate GIS officer at the Glowinthedark Uranium Mine in outback Australia. The mine has been operational for fifteen years. It is expected to be operational for a further forty years. All survey marks at the mine have geodetic coordinates on the Australian Geodetic Datum 1984 (AGD84). In addition there is extensive mapping of the mine's infrastructure and ore body.

The mine's surveyor, Jack Longtooth, has been with the mine ever since it opened. Jack has done as excellent job but has become very set in his ways and is reluctant to embrace change and new technologies. "If it ain't broken, don't fix it" is frequently heard coming from his office, particularly when the possibility of converting to the new Geocentric Datum of Australia (GDA94) is mentioned.

Jack's mistrust of new technology was strengthened following a recent experience with a GPS receiver. Acquired by the mining company against Jack's advice, Jack was particularly scathing when the receiver produced coordinates that were 200 metres different from those on the map (approximately 170 metres in northing and 120 metres in easting). The receiver has been gathering dust at the back of a cupboard ever since.

Jack will shortly retire. The management of the mine is desperate to modernise the surveying and mapping operations at the mine and has employed Joe for this purpose. They are particularly perplexed by the apparent failure of the GPS receiver ("Our competitors aren't having this problem") and seeking Joe's advice as to how they should proceed. They also aware that GDA94 coordinates now exist for six AGD84 national survey marks in the vicinity of the mine.

(a) Explain to Jack and the mine management (in terms of local and geocentric datums) why there is a 200 metre discrepancy between the GPS receiver coordinates and AGD84 coordinates on the map.

(b) Would conversion to GDA94 overcome the apparent problem with the GPS receiver? Give reasons for your answer.

(c) The mine is interested in converting its spatial information systems from AGD84 to GDA94. What transformation techniques would you employ (give reasons) to convert:

1) The mine's survey mark coordinates which are accurate to 3 cm.
2) The file containing positions of environmental sites which are accurate to 20 metres
3) The file containing the mine's road network which is accurate to 1 metre

**(13)**

# PART B

## QUESTION 1

(a) Describe the three segments of the Global Positioning System (GPS).

(b) Discuss the nature and characteristics of the signals transmitted by the GPS satellites.

**(10)**

## QUESTION 2

(a) Describe the principles of the pseudoranging technique for GPS positioning.

(b) Describe the method of Differential GPS positioning using pseudoranges. What are the advantages and disadvantages of Differential GPS positioning when compared with GPS point positioning?

**(10)**

## QUESTION 3

(a) Discuss the principles employed when processing GPS carrier phase measurements to produce high-accuracy relative positioning.

(b) Describe the differences between the following modes of GPS (carrier phase) operation.

1) Static Mode
2) Rapid Static Mode
3) Stop-and-Go Mode
4) Real Time Kinematic Mode

**(10)**

## QUESTION 4

Identify the error sources that affect the accuracy of GPS measurements. Discuss techniques for minimizing or removing such errors.

**(10)**

## QUESTION 5

A GPS vector has been measured between points D and E using carrier-phase techniques. The vector components from D to E in geocentric Cartesian coordinates on the WGS84 datum are:

| | |
|---|---|
| Difference in X - | 10115.279 metres |
| Difference in Y - | -7529.550 metres |
| Difference in Z - | 6112.112 metres |

The AMG coordinates of point D (on the Australian Geodetic Datum 1984 (AGD84)) are:

| | |
|---|---|
| Zone - | 54 |
| East - | 350113.226 |
| North - | 6325226.229 |
| Height - | 57.622 metres (above sea level) |
| Geoid-spheroid separation - | +13.22 metres |

The geoid-spheroid separation at point E relative to AGD84 is 15.17 metres.

DESCRIBE the sequence of processes that you would apply to calculate AMG coordinates and height above sea level at point E. DO NOT PERFORM THE COMPUTATION.

**(8)**